# MISSOURI BOTANICAL GARDEN

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# Bulletin

January 1961
Volume XLIX
Number 1

COVER: Thoroughfare for Automobiles Lined with *Roystonea regia* in Botanical Garden and Botanical Institute of Caracas, Venezuela. Photo by Julian A. Steyermark.

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Missouri Botanical Garden Bulletin

Vol. XLIX No. 1 January 1961

# BOTANICAL GARDEN AND BOTANICAL INSTITUTE OF CARACAS, VENEZUELA

JULIAN A. STEYERMARK

ONE OF the show spots in the glamorous city of Caracas, Venezuela, is, without doubt, the Botanical Garden and Botanical Institute. Started 15 years ago in 1945 by Dr. Tobias Lasser, who has been its able director since the beginning, the Botanical Garden (Jardin Botanico) is part of the great university of Caracas (Universidad Central de Venezuela). It is a large green park comprising 70 hectares (174 acres approximately) nestled along the southern margin of the mountain valley in which Caracas is located. A large part of the Botanical Garden is hilly, occupying the southern slopes of a range of small mountains adjacent to the Caracas valley.

The garden was established for the purpose of growing all the species of plants which can be cultivated in Caracas, including native as well as foreign species. One of the objectives is to grow as many native Venezuelan species as is possible at this altitude (approximately 3000 feet above sea level) and temperature (68.9° F. average). Of approximately 2,500 species of plants in cultivation in the garden, about 70% are native species of Venezuela. Over 200 different species of trees are grown here. The garden is maintained by Mr. Augusto Braun, the chief gardener, who is a well-trained Swiss horticulturist.

The Botanical Garden is laid out in several sections: 1) the Succulent plant collection, which features many plants characteristic of desert or arid regions of Venezuela, other parts of South America, Mexico, and Africa; 2) the Economic plant collection, containing plants grown for their medicinal properties or for their value horticulturally, or in connection with foods, fibers, resins, gums, and latex; 3) the Palmetum, devoted to the culture of nearly 100 species of palms; 4) the Aquatic plant collection, which is grown in a number of pools and small lakes scattered throughout the garden; 5) the Conservatory, housing various kinds of tropical plants demanding humidity, shade, and protection from wind; 6) the Orchidarium, containing a diversified collection of orchids; 7) a Nursery section devoted to the growing of seeds and the reproduction and multiplication of various plants for other parts of the garden; 8) the Tropical Forest section, showing an extensive naturalistic presentation of trees, shrubs, vines, and herbaceous plants as they are ordinarily seen growing in tropical rain forests. This

last section especially is one of the most fascinating in the entire botanical garden. Here one walks along trails in the midst of what seems to be real tropical rain forest, with many kinds of ferns, aroids, palms, Marantaceae *(Colothea, Maranta, Ischnosiphon)*, Zingiberaceae *(Costus, Hedychium)*, Amaryllidaceae *(Curculigo*, species of *Heliconia, Begonia, Pilea, Peperomia,* and various ground covers. The forest canopy is topped by various trees of el miao *(Anacardium rhinocarpus)*, matapalo *(Ficus* spp.*)*, copey *(Clusia* sp.*)*, jabillo *(Hura crepitans)*, bucare *(Erythrina* sp.*)*, and caro *(Enterolobium)*. The effect produced is truly amazing for its realistically natural beauty.

The forested hills rising above the valley of the garden impart a large area of green cover and wild beauty to Caracas, and, together with the adjacent forested park of Los Caobos (the Mahogonies literally, these trees dominating the park) and other parks scattered throughout the city, help to sustain a more healthful and purified atmosphere. These hills have been reforested among the existing large original trees of *Swietenia* (mahogany), *Anacardium, Ficus, Erythrina, Hymenaea, Lonchocarpus, Machaerium,* and *Enterolobium,* and smaller trees and shrubs belonging to the genera *Prockia, Clusia, Erythroxylon, Randia, Rondeletia, Gauzuma, Citharexylum, Trichilia, Bauhinia, Cap-*

Portion of Succulent Collection, showing Cacti, Agave, and Yucca.
PHOTO BY J.A.S.

PHOTO BY J.A.S.

Scene in Tropical Forest Section with Polypodium fern in foreground and Philodendron at right.

*paris, Trema, Roupala,* and *Ximenia.* About 150,000 trees have been planted, with an average of 10,000 planted each year. Within twenty years from the time of planting, these trees will have become large enough to effect a true woodland condition. Some of the trees which have been planted include species of *Astronium, Clusia, Tabebuia, Ficus, Persea, Platymiscium, Jacaranda, Erythrina, Cordia, Machaerium, Lonchocarpus,* and *Cassia.* These have been planted with the aim of knowing which trees will thrive best on the deforested sections of slopes of the Avila Mountain, which lies along the north side of the valley of Caracas. This is an important project in the botanical garden, since each Minister of Agriculture considers as his pet project the reforestation of the Avila Mountain. Although emphasis is thus placed on reforestation with native subjects, some plantings have been given over to foreign species of *Eucalyptus, Casuarina,* and *Cassia siamea.* The section of forested hills described here constitutes the Arboretum, featuring more than 70 different kinds of trees. In the valley section of the garden are also many kinds of trees arranged according to their respective families.

The section of the reforested hills section of the Arboretum is not wa-

tered, since it occupies too large an area. The remainder of the garden, however, is given water regularly during the months of the dry season, most especially from December to mid-April.

The Botanical Institute (Instituto Botanico) is situated within the Botanical Garden. It is under the direction of the Department of Renewable Natural Resources (Recursos Naturales Renovables) of the Ministry of Agriculture (Ministerio de Agricultura y Cria) of Venezuela. Dr. Lasser is also director of the Botanical Institute. The building in which the institute is housed is a beautiful modern structure, in harmony with other parts of the adjacent university. Here are located the herbarium, library, lecture rooms, laboratories, and offices of the staff. The latter consist of Dr. Lasser, Dr. Leandro Aristeguieta, curator of the herbarium and specialist on Compositae and *Heliconia*, Dr. Valkmar Vareschi, ecologist and specialist on ferns and lichens, Dr. Ernesto Foldats, specialist on orchids and marine algae, Dr. Zoraida Luces de Febres, specialist on grasses, and the present author.

Modern fluorescent lighting illuminates the various rooms of the Botanical Institute, and beautifully planted patios give color and gaiety to the surroundings. In one of the patios adjacent to the herbarium and offices there is a pool filled with tropical white and purple ever-blooming water lilies *(Nymphaea)*. Their fragrance and color lend constant charm and interest to the beautiful surroundings.

The herbarium (Herbario Nacional de Venezuela) occupies a large air-conditioned room containing numerous modern steel cabinets. Approximately 100,000 herbarium specimens are lodged in these cases, 95% of the specimens originating from Venezuela. The purpose of the herbarium is to bring together and maintain as complete a collection as possible of the Venezuelan flora, which is estimated at least at 20,000 species of vascular plants. Continued exploration of various parts of Venezuela by staff personnel, as well as by botanists from the United States and other countries, is constantly adding genera and species previously unrecorded from Venezuela, as well as numerous species new to science. This is especially true from collections made in the southern half of the republic. Publication of an illustrated flora of Venezuela is being planned and is in actual state of progress. The herbarium, of course, is an indispensable tool for the implementation of such a work.

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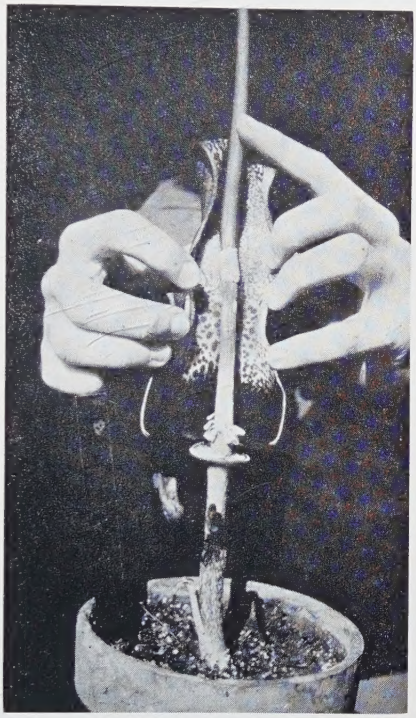
Dr. Julian A. Steyermark is now with the Botanical Garden and Botanical Institute of Caracas, Venezuela. In cooperation with the New York Botanical Garden he is making a plant collecting expedition into the virgin forest section of Venezuela near the British Guiana border.

# THE VOODOO LILY — DIME-STORE MAGIC

GEORGE S. BUNTING

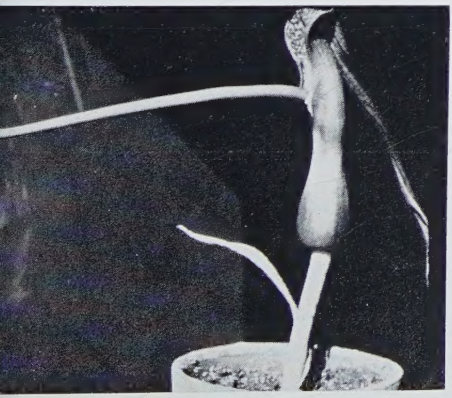
SUCH A bizarre aroid as *Sauromatum guttatum*[1] deserves greater popularity. Its blossom grows from a bulb-like corm at a remarkable speed; a corm set on a windowsill may, within six weeks, bear an inflorescence such as pictured here. The blossom consists of a spike (spadix) enclosed within a sheath (spathe) that is bronze-olive outside.

As the sheath partially unfurls, the tip of the spadix greatly elongates and bends forward. The part of the spadix just inside the mouth of the spathe bears a zone of yellow male flowers, below which is a long barren area. Near the base of the spadix is a zone of female flowers with a group of much-enlarged sterile flowers just above. As the pollen is shed from the male flowers, the very elongate terminal portion of the spadix begins to emit an odor not very different from that of decaying meat. Needless to say, this feature may have some effect on the popularity of this species, but it should not. This barren part of the spadix should be cut off and discarded at the first suggestion of any odor, and the blossom will be scarcely less fascinating.

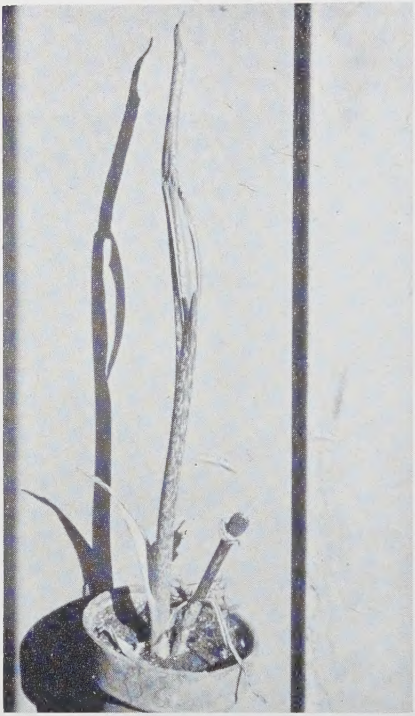


Handsome coloring on the inside of the spathe is never completely exposed.

An inflorescence of the Voodoo Lily may reach 12″ or more in length before it unfurls to expose the 9″ pencil-like appendage of the spadix.



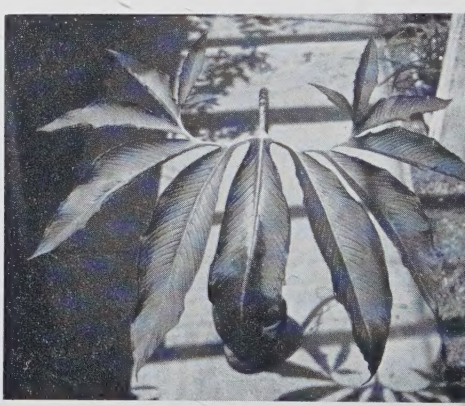
Though interesting enough externally, it is the inside of the spathe that is bizarrely colored—purple-spotted on a background of yellow that becomes white in the tube, the basal part a rich velvety purple. The coloring of the



The mottled leaf stalk elongates rapidly as the inflorescence fades, but the divided leaf blade unrolls slowly.

spathe and the odor emitted by the spadix closely imitate that of aging meat. This is an excellent example of mimicry in plants—an adaptation that, in its native habitats in southeastern Asia, attracts carrion-loving insects. In crawling over the flowers, these insects transfer pollen from the male flowers of one plant to the female flowers of another, thus bringing about the pollination necessary for seed production.

For the sake of one blossom, it is unnecessary to pot the corm in soil, but it is recommended. If planted, watering should be held to a minimum for several weeks until growth commences. As the blossom fades and the single leaf begins to appear, watering may be more frequent. The large leaf is umbrella-like, divided into 9–11 segments in a vigorous specimen, and borne on a brown-mottled stalk to three feet long. To maintain the same corm for growth in subsequent years, the leaf must be permitted to grow to maturity. The plant should be treated like other growing plants. Finally, the leaf will die down, and a rest period ensues, during which less watering is required. A well-established bulb may begin to push up a new blossom in mid-November and flower by Christmas.



When mature, the much-divided leaf may be two feet across.

Indoors, plant several corms of the Voodoo Lily in one pot. The effect will be better, especially when the leaves appear. If planted in the garden rather deep, and mulched heavily in winter, *Sauromatum* will probably over-winter out-of-doors. A closely-related species, *Arum italicum*, is reliably hardy in the St. Louis area.

[1] Sometimes this species is erroneously called *Arum cornutum*.

# MISSOURI BOTANICAL GARDEN
# 1961
# EDUCATIONAL PROGRAMS

## ACTIVITIES FOR CHILDREN

A SUMMER Nature Program made possible by a grant from the Pitzman Foundation is offered for children ages 7 to 17. Children have a fundamental curiosity about everything going on around them and these summer courses given by the Garden encourage this interest in living things and answer many questions that arise from a closer contact with nature.

Registration for the first session will be June 19th and for the second session July 24th. Further information about the courses and registration will be available at the Main Gate after May 1st, telephone PRospect 6-1785.

Free Nature Programs for children, ages seven and over, are held every Saturday morning from 10:00 A. M. to 11:30 A. M. in the old Museum Building (enter at Cleveland Avenue gate) or elsewhere as may be announced.

For further information call PRospect 6-5567

A Group of Children in Rapt Attention as Mr. Kenneth Peck Instructs Them in How to Identify Kinds of Trees by Their Leaves. PHOTO BY GLOBE DEMOCRAT

## Program for Saturday Activities for 1961

### A. First Six Months—January through June

January
- 7 Dead or Alive
- 14 Winter Puzzles
- 21 Do You Have a Green Thumb?
- 28 Jungle Plants

February
- 4 The Mystery of the Orchid
- 11 The Green Thumb at Work
- 18 Color Sound Movies
- 25 Plants in a Capsule

March
- 4 Three Cheers for the Green Thumb (you may take your plants home)
- 11 The Life Secret of a Plant
- 18 The Story of the Pincushion Forests
- 25 Make Your Own Dwarf Garden (bring your own container)

April
- 1 Sowing Seed for Your Garden
- 8 Flower Shapes and Names
- 15 Hunting for Hidden Flowers
- 22 Spring Safari
- 29 More About Your Garden Seeds

May
- 6 Plants from Historic Times
- 13 Planting Your Garden
- 20 Color Sound Movies
- 27 Plants with Wet Feet

June
- 3 What Is a Tree?
- 10 Exploring the Underworld
- 17 The Queen of Flowers
- 24 Shades of the Night

### B. Second Six Months—July through December

July
- 1 Color Sound Movies
- 8 The Grasses
- 15 Life in the Desert
- 22 Algae, Food of the Future
- 29 The New Generation

August
- 5 Color Sound Movies
- 12 Dangerous Plants
- 19 Table Top Greenhouse
- 26 Gardening through the Ages

September
- 2 Plants for the House
- 9 Hundred in one Flower
- 16 Color Sound Movies
- 23 The Devils Footstools
- 30 From Dust to Seed

October
- 7 Fall's Carnival
- 14 Fall's Frolic
- 21 Planting Bulbs
- 28 Witches Brew

November
- 4 Color Sound Movies
- 11 The Rise of Forests
- 18 Woodlands of America I
- 25 Woodlands of America II

December
- 2 Insectivorous Plants
- 9 Make Your Own Christmas Decorations
- 16 Make Your Own Christmas Decorations
- 29 Color Sound Movies

## COURSES FOR ADULTS IN HOME GARDENING AND BOTANY

The Garden is offering a series of courses for the Home Gardener and a similar series for those interested in Botany. The courses may be taken as independent units. However, anyone satisfactorily completing the two basic courses and eight additional courses, six of which are in the major subject, are eligible to receive a Certificate of Achievement.

The courses will be open to all interested persons. The fees charged for the adult courses include all materials. The field trips will be arranged by consultation with the groups concerned. Most classes and practice sessions will be held in the classroom and greenhouses of the Garden's Experimental Greenhouses which can be reached by entering the Cleveland and Tower Grove Avenue gate.

Registration for all courses must be made in advance as the number of persons who can be accepted for a given course is limited. Should interest warrant, second sessions will be considered. Should less than twenty persons register for any course, it may be dropped in which case the fees will be refunded.

All courses will be taught by Garden Staff members and by selected specialists. Fees based on amount of time and materials supplied by the Garden.

## A. Home Gardening

101. Home Garden Preview *Basic Course*
For the home owner, a non-technical basic course including facts and procedures for planning, planting, pruning, fertilizing, watering and general maintenance of home grounds.

102. Plants for Your Garden *Basic Course*
Introduction to cultivated plants for particular places and uses. How to identify and recognize them by actual study of material in the laboratory and in the field.

103. Garden Planning and Design. To be given in 1962.

104. How to Propagate from Seed.
Fundamental facts and procedures for producing annuals, biennials and some perennials from seed for use in your garden. The Garden supplies seed, germinating media and soil for four metal flats of seedlings which you may take home. Persons wishing to supply their own seed must bring it to the first session.

105. How to Propagate from Cuttings.
Fundamental facts and procedures of producing trees, shrubs and perennials from cuttings (asexual reproduction). The Garden will supply one plastic covered metal propagating flat, media and plant materials for 40 to 50 kinds of plants.

106. Home Food Garden.
General instruction in the facts and procedures for preparation and maintenance of a home food garden. Plant selection, control of weeds, pests and other problems confronting the home gardener. Attention to individual problems will be given.

107. Bulbs Indoor–Outdoor.
Instruction on bulb forcing and outdoor bulb culture will be given. The Garden will supply each student with 24 top quality bulbs in 7 inch clay pans which may be taken home. The Garden will also provide space for cool treatment which the forced bulbs require.

108. House Plants.
General instruction in the kinds of house plants, care and growing requirements such as heat, light, water and fertilizer will be given. Attention will be given to individual home problems.

109. Preparation and Care of Lawns.
General instruction concerning the preparation, care and maintenance of lawns. Special attention will be given to individual problems.

110. Home Orchid Culture.
Orchids suitable for home culture and best ways of growing them. Potting demonstration and practice. Students may take the plant they pot home.

111. Plants under Artificial Light. To be given in 1962.

112. Area Management. (For persons with small acreages or estates).
Practical instruction on erosion control, weed and brush control and basic management of ponds. Specialized instruction in management of meadows, marshes and forests will be explained, emphasizing recreation and wildlife.

## B. Botany

201. Botany for Beginners. *Basic*
General instruction in botany. A semi-technical course to give the amateur an understanding of the plant world.

202. Plant Materials. *Basic*
General instruction to enable the student to identify and recognize many forms of plant life. Students will work with living material in the laboratory. One session will be a field trip.

203. Ecology. To be given in 1962.

204 & 205. Field Botany.
Field courses are designed to enable the student to recognize common wild flowers and weeds in the field in the Spring and in the Fall, and to understand plants' relationship with their environment.

206. Economic Botany.
General instruction in useful plants and their relation to man are studied, using the Garden's extensive collections of materials from archeological sites, primitive culture and modern breeding experiments.

207. Mosses (A) and Ferns (B).
General instruction in mosses and ferns. Participants will learn how to identify and to recognize the

common kinds. Two sessions will be field trips.

208. Genetics. To be given in 1962.

209. Survey of Grasses.
The student will learn how to identify and to recognize the common grasses of fields and lawns.

210. Survey of Orchids.
The student will learn how to identify the many unusual and common orchids, using the Garden's large collections.

211. Plant Physiology. To be given in 1962.

212. Paleobotany. To be given in 1962.

## Schedule of Courses in Home Gardening

| No. | Title | Number of Sessions | Fee | Day of the Week | Date of the Month | Time of the Day |
|---|---|---|---|---|---|---|
| 101 | Home Garden Preview, *Basic* | 8 | $10.00 | Tues. | Jan. 10 to Feb. 28 | 8:00 to 9:30 P. |
| 102 | Plants for Your Garden, *Basic* | 8 | $10.00 | Tues. | Apr. 25 to June 6 (One session is a field trip to be arranged.) | 8:00 to 9:30 P. |
| 103 | Garden Planning and Design | To be given in 1962 | | | | |
| 104 | How to Propagate from Seed | 5 | $12.00 | Tues. | Mar. 14 and 21 Apr. 4, 11 and 18 | 1:00 to 2:30 P. |
| | | | | Thurs. | Mar. 16 and 23 Apr. 6, 13 and 20 | 8:00 to 9:30 P. |
| 105 | How to Propagate from Cuttings | 5 | $12.00 | Tues. | Oct. 17 to Nov. 14 | 1:00 to 2:30 P. |
| | | | | Thurs. | Oct. 19 to Nov. 16 | 8:00 to 9:30 P. |
| 106 | Home Food Garden | 3 | $ 6.00 | Thurs. | Apr. 20, May 4 and 11 | 8:00 to 9:30 P. |
| 107 | Bulbs, Indoor–Outdoor | 2 | $ 8.00 | Tues. | Oct. 3 and 10 | 1:00 to 2:30 P. |
| | | | | Thurs. | Oct. 5 and 12 | 8:00 to 9:30 P. |
| 108 | House Plants | 3 | $ 6.00 | Thurs. | Oct. 5, 19 and 26 | 8:00 to 9:30 P. |
| 109 | Preparation and Care of Lawns | 3 | $ 6.00 | Tues. | Aug. 8, 15 and 22 | 7:00 to 9:00 P. |
| 110 | Home Orchid Culture | 1 | $10.00 | Sat. | April 8 | 10:00 to 3:00 P |
| 111 | Plants Under Artificial Light | To be given in 1962 | | | | |
| 112 | Area Management | 4 | $ 8.00 | Wed. | Feb. 1 to 22 | 8:00 to 9:30 P. |

## Schedule of Courses in Botany

| No. | Title | Number of Sessions | Fee | Day of the Week | Date of the Month | Time of the Day |
|---|---|---|---|---|---|---|
| 201 | Botany for Beginners, *Basic* | 8 | $10.00 | Thurs. | Jan. 5 to Feb. 23 | 8:00 to 9:30 P. |
| 202 | Plant Materials, *Basic* | 8 | $10.00 | Tues. | Apr. 25 to June 6 (One session is a field trip to be arranged.) | 8:00 to 9:30 P. |
| 203 | Ecology | To be given in 1962 | | | | |
| 204 | Field Botany—Spring | 3 | $ 6.00 | Sat. | May 20, 27 and June 3 | Start from Gar 10:00 A. M. |
| 205 | Field Botany—Fall | 3 | $ 6.00 | Sat. | Sept. 23, 30 and Oct. 7 | Start from Gar 10:00 A. M. |
| 206 | Economic Botany | 5 | $10.00 | Wed. | Mar. 15 and 22, Apr. 5, 12 and 19 | 8:00 to 9:30 P. |
| 207 | Mosses and Ferns | 5 | $10.00 | Wed. | Oct. 4, 11, 18 and 25, Nov. 1 | 8:00 to 9:30 P. |
| 208 | Genetics | To be given in 1962 | | | | |
| 209 | Survey of Grasses | 3 | $ 6.00 | Thurs. | Aug. 10, 17 and 24 | 7:00 to 9:00 P. |
| 210 | Survey of Orchids | 5 | $10.00 | Wed. | Apr. 12, 19 and 26, May 3 and 10 | 8:00 to 9:30 P. |
| 211 | Plant Physiology | To be given in 1962 | | | | |
| 212 | Paleobotany | To be given in 1962 | | | | |

# COOPERATION, A FACTOR IN PLANT INTERACTIONS

LILLIAN OVERLAND

SCIENCE, because of the great complexity of life, is constantly faced with the pitfall of erroneously explaining any major process, either due to over emphasis of any one aspect, regardless of its individual validity, or through ignorance of equally important ones.

Such is probably the case with the role of "struggle for existence" in evolution. Strangely enough, it was not Darwin himself who was directly responsible for this situation. For although he sought to explain evolution on the basis of natural selection operating through competition and struggle, he was aware that other important factors were involved, and warned that the term "struggle for existence" must be used in a large and metaphorical sense to include dependence. Perhaps the social and economic situation of the day had a decisive influence in the matter, for during the turbulent time of the Industrial Revolution, when much doubt as to the wisdom of the drastic changes must have existed, Darwin's theory seemed to provide a natural justification of human struggle and cupidity based on the "red claw" concept of nature. Superficially it was possible to provide much apparently supporting evidence, and thinking, for the most part, became channeled in this direction. Thus, although competition doubtlessly exists, the failure to recognize other equally, if not more important, aspects, resulted in a false overall picture of natural selection. This no doubt set back scientific progress considerably.

Lost, however, among the general opinions of the day were forerunners of other ideas. Despite his belief that plants in a given area are in a constant state of war, de Candolle, in 1820, observed that when conditions favor a large number of species to the same degree, plants will live together in a mixed community. Although he could not explain why this is so, it clearly indicated that there must be other forces than competition in operation, or the result would be one dominant species. Nägeli later confirmed this. He found that no matter how strong the competition is, plants, as a rule, do not suppress each other to the degree that one alone persists in the habitat where it is stronger, but on the contrary, they tolerate each other in the same situation and competition operates reciprocally upon the number of individuals, and then only between similar plants which are under similar conditions. Competition, therefore, cannot be regarded as an active struggle, nor the sole force; interdependence and cooperation are of necessity implied.

This idea was further expanded by other scientists such as Macmillan and Clements, who compared the flora of a region with the condition of mutual interdependence and competition in human society. The comparison between plant and animal, including human communities, is valid insofar as all have mutual dependence and reciprocal influences among many types of individuals, giving rise to organized division of labor with all

working for the benefit of the whole community. A community, thus, is not a mere grouping, but the result of interaction of plants and of numerous interdependent factors, one of which is competition.

As Darwin had earlier indicated, Clements, in 1905, actually confirmed from detailed competition studies, that "struggle for existence," except in such organisms as parasites, is true only in a figurative sense. With adequate water, nutrients, and light, he found that competition ceases and starts again only when one factor is limited. It then occurs mostly between like species with similar needs and never results in the elimination of all associated species. The idea of aggressive struggle and mechanical competition, in view of this, must be seriously questioned.

In a broad sense, perhaps the most obvious evidence is found in the mere coexistence of such a wide range of species. Were the theory of natural selection by survival of the fittest correct, literally, then we would expect only a very few highly specialized forms to have survived. Lower plants such as algae, mosses, and ferns, should either have been completely eliminated by now or should be on the way out. No such evidence exists. On the contrary, we find a complete range from lowest to highest plants as well as animals living side by side in apparent harmony. It is also interesting to note that the most highly developed group of plants, the Compositae, represent an advanced form of cooperation by having a multiple flower enclosed within one corolla.

The animal kingdom similarly reveals the importance of cooperation. In his remarkable book, "Mutual Aid, a Factor of Evolution," Kropotkin, in 1902, concluded:

> "We may safely say that mutual aid is as much a law of animal life as mutual struggle but that as a factor of evolution it most probably has a far greater importance inasmuch as it favors the development of such habits and characters as insure the maintenance and further development of the species together with the greatest amount of welfare and enjoyment of life for the individual, with the least waste of energy."

Since cooperation is, thus, at least as important or probably more so than competition in the operation of natural selection, he felt that the elimination of the latter created better conditions.

In support of this view is the fact that since Darwin's time there has been no actual evidence to show that the "extinguisher" is the fittest. On the contrary, anthropologists such as Ashley Montagu have presented numerous examples from the highest animal, man, to support the idea that mutual aid and cooperation are the dominant principles of life, and that cooperative processes, though not the only ones, are characteristic of all living beings.

Although it cannot be put to a scientific test, perhaps man's intuition provides some of the best supporting evidence. For, as an intelligent being produced by evolution, it is not improbable that within the depths of his mind are vestiges of the past as well as indications of the future. He alone of all animals can measure his natural success, or compliance with the laws

of nature, in terms of peace or happiness, and intuitively he recognizes the law of cooperation. Although it might be violently argued that egotism and competition are often the greatest driving forces of life, the acid test seems to lie in the fact that basically it is harmony and cooperation which provides man's deepest satisfaction and truest human progress. These drives start at birth; from the state of a helpless infant which must be protected and cared for, man develops into a gregarious social animal who can find true fulfillment only through interaction with his fellow man. If this is any indication of natural law then it may be implied that cooperation is a stronger force and perhaps an indication of future development, whereas much of competition might be regarded as a primitive characteristic. By the same token, war may be regarded as an aberration with no biological support. For it was only through cooperation that, regardless of relative physical weakness, a highly complex being was able to evolve from a simpler one. Or, as stated by the philosopher, Bergson:

> "The real facts of evolution were to be found, not in a mechanical elimination of the unfit, but in the creative surge of life . . . "

In 1944 a group of American biologists summed up the principle as follows:

> "The probability of survival of living things increases with the degree in which they harmoniously adjust themselves to each other and to their environment. Natural selection favors cooperation. We begin to understand then that the process of evolution is one which favors cooperating rather than disoperating groups and that "fitness" is a function of the group as a whole rather than separate individuals. The more cooperative the group the greater is the fitness for survival which extends to all its members."

The habit of thinking in terms of "struggle for existence" and ruthless condemnation of the weakest is not only incorrect, but has done much harm. For because of the overemphasis, very little effort has been made to elucidate other factors, with the result that the field is largely unexplored. What information does exist is scanty and often contradictory. The time is ripe, therefore, to start looking seriously for the mechanisms which might explain plant interactions, and especially the role of cooperation. It is to this end that a large part of the research at the Garden will be directed.

### Plant Interactions

To date, most work on plant interactions has dealt chiefly with the more obvious factors of water, nutrient, temperature, light, etc. Although much more remains to be learned about each of these, a final understanding can come only through the correlation of all possible factors. Consequently, it is of equal importance to investigate relatively little understood or unsuspected ones.

Among the latter class is the highly controversial question of plant secretions. For a long time it was disputed as to whether or not normal plants excreted substances which could be absorbed by others, thereby exerting an influence on them. Today, although still far from complete, we have sufficient evidence to believe that

this is so. Experiments have demonstrated that roots are able to absorb not only inorganic substances but also relatively large organic molecules and consequently it is possible for neighboring plants to influence each other's chemical composition through mutual secretions. Even very small quantities which are difficult to measure may play an important role, as shown by the great effect of very small amounts of plant hormones.

Influenced perhaps by the concept of competition, it is not surprising that early ideas and investigations in this field were concerned with inhibitory secretions. Although they supply most of our present evidence for plant secretions, as we shall see later, there is another side.

De Candolle's theory of Antagonism stated that all plants excrete toxic substances which stay in the soil for a long time and are especially effective on the same species. More recent work by Schreiner has confirmed that soils of reduced fertility do contain toxic substances such as picolonic acid, salicylaldehyde, vanillin, and others, and may account for "soil fatigue." Crop rotation, therefore, is based at least partly on root secretions.

Some of the most decisive evidence for plant secretions came from studies by Went and Bonner of typical desert shrubs such as *Encelia* and *Artemisia*, which occur widely spaced with no plants growing beneath them. They showed that this is a result of toxic substances contained in their leaves, which when washed to the ground by rain, inhibit seedlings. They were able to extract and partly identify, chemically, the responsible substances. Similarly, water extracts of a rubber plant (Guayule) which also inhibits seedlings growing beneath it, were found to contain toxic substances.

Other experiments in which water extracts were used, support the above evidence that plant secretions may play an important role. Among such cases are the following:

Grasses are known to affect fruit trees. When water was passed through living roots of grass and then applied to apple trees, a definite inhibition of growth occurred. Similarly, extracts of quack grass *(Agropyron repens)* inhibited alfalfa and wheat.

A substance, juglan, one which can be removed by water from black walnut tree roots, causes inhibition to other plants such as tomato and alfalfa, thus partly explaining the general toxic effects of this tree.

Peach trees, which are difficult to reestablish in old orchards, also yielded a root secretion which was toxic to its own seedlings.

Many cereals have long been known to have a protective mechanism against common weeds. The most effective of these, such as barley, wheat, rye, oats, and flax, are called "Smother Crops," a name based on the idea that they operate mainly through smothering effects of extensive roots and leaves. However, recent experiments carried out here have indicated that there must be other factors. When grown together with adequate nutrient, water, etc., thus eliminating competition, barley still suppressed both chickweed and tobacco. When planted above chickweed, the effect of

barley was much greater than when it was below, thus showing that something must be carried down with rain water from the barley to the chickweed, which inhibits it. Furthermore, water extracts of barley seeds and roots inhibited the germination of chickweed to a large extent but hardly affected tobacco. On the other hand, it has been found by others that extracts of sprouted barley seeds have a beneficial effect on the growth of sugar beet. All this implies that we are dealing with a secretion which is capable of acting very differently on different plants and at different stages of their development. This leads to another very important side of the question of secretions.

Although scientific research is theoretically supposed to be objective, it is clear that only when one looks shall one find, and if one looks only in one direction, one will find only what lies therein. Thus, in the case of root secretions, which may now safely be assumed to play a role of greater or lesser importance in plant interactions, mainly those of toxicity or inhibition have been studied. This occurred despite the long known facts pointing to beneficial relationships.

For instance, farmers have long known and profited from the fact that certain crops do much better when planted with others. Examples are early potato with late cabbage, potato with tomato, tomato with bush bean, bush bean with celery, carrots with peas, and wheat with corn. Also, certain forest trees are known to be especially compatible, such as birch with ash, ash with beech, pine with alder. Many seedlings do best when planted together with others, such as pine with linden, oak with willow, and beech with spruce.

Evidently no one has ever seriously tried to find the reasons for the above relationships. Possible explanations in such terms as mechanical support, reduction of disease carrying microorganisms, etc., have been proposed but never proved. It remains to test some of these known cases under controlled conditions in order to arrive at the answer. It cannot be presumed, of course, that secretions are involved here, but in view of the knowledge of inhibiting ones, it is not unreasonable to predict that possibly beneficial ones might also exist, and consequently should be looked for.

Such evidence is not entirely lacking. For instance, the liberation of significant quantities of nutrient elements in normal root metabolism is known to be widespread. After flowering, there is a normal elimination of inorganic salts, especially phosphorus from legumes and root crops. Roots of legumes are able to dissolve and absorb highly insoluble phosphorus compounds, followed by the excretion of phosphorus salts which can then be absorbed by less vigorous feeders. Also, roots secrete sugar and malic acid, both important in normal mineral nutrition. The exact function of such secretions in plant communities remains to be determined.

Among the most interesting and concrete known cases of beneficial secretions is that of the parasite, *Striga*, which grows on roots of other plants such as soy beans, and cannot germi-

nate unless a host root secretion is present. It has been found that, to a certain extent, this substance may be replaced by the chemical, allyl thiourea. Here then is an unusual case of obligatory cooperation. What other functions, if any, the host root secretion serves, is now known.

Still of greater surprise perhaps are cases of weeds known to have favorable effects on crops, for example *Sisimbrium officinalis* on oats.

We begin to see, therefore, that there are two sides to the problem. The whole phenomenon of symbiosis, or the co-existence of two or more organisms to the mutual benefit of each which has previously been studied mainly with respect to lower plants, might well apply to higher plant interactions as well.

Because of the incomplete state of current knowledge, it cannot be said to what extent secretions, beneficial or harmful, actually play a role in nature. Many coexisting factors such as soil microorganisms capable of converting excreted substances from one form to another, must be taken into consideration. Other evidence indicates that there is no sharp line of demarkation between harmful and beneficial excretions. Concentration alone may make the difference, as is the case with quack grass where extracts of roots in low concentration stimulate rape and oats, but in high concentration greatly retard them. Or, the stage of development may influence the effect. For example, wheat is stimulated by rye in its early growth stages, but is inhibited after flowering; the effect of wheat on rye is the reverse. Experiments employing appropriate extracts showed that the change is due to mutually absorbed substances secreted by both species.

From the foregoing it is clear that much more research is called for in order to solve the general problem of the role of plant secretions. Since in nature there are too many uncontrollable factors, it is essential to carry out many experiments under controlled conditions. After confirming the existence of and studying the biological action of secretions, the next step is to identify chemically the active substances. Finally, and most difficult, is the fitting of this factor into its perspective role in nature, for the final explanation of plant interactions and their function in evolution can come only from an understanding of the balance of the many interacting factors. To this end, the cooperation of many specialists such as the botanist, biochemist, and ecologist is required.

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## SOME FACTS ABOUT SHAW'S GARDEN

The Missouri Botanical (Shaw's) Garden was established in 1859 by Henry Shaw, a St. Louis businessman, to be controlled by a Board of Trustees for the public benefit. The Garden is a non-profit institution which receives no support from the city or state, depending on the income from the Shaw estate supplemented by contributions from the public.

The old stone walls and cast-iron fences, the Linnean House, the Museum Building, the part of the Administration Building which was Shaw's Town House, relocated in the Garden in 1890, and the Tower Grove House, his country home, all date from Mr. Shaw's time. The Main Gate, display and growing greenhouses and most other facilities date from the period immediately following the turn of the century. The Climatron, opened in 1960, is the first of several new buildings planned for the Garden's redevelopment. It is the world's first geodesic dome, fully climate-controlled greenhouse and contains the Garden's tropical collections.

The Garden — 70 acres — is open every day of the year (except Christmas and New Year) from 9 A.M. until sundown, and the greenhouses close at 5 P.M. Tower Grove House is open daily from 1 P. M. to 4 P. M. (December to March on weekends only). The Display House presents four seasonal displays:— November, Chrysanthemums; December, Poinsettias; February, Orchids; Spring, Lilies and other flowers. During the year are other shows, competitions and festivals sponsored by various Garden Clubs and Flower Societies.

Courses in Botany and Horticulture for adults are conducted by the Garden staff. Children's nature studies are provided each Saturday of the year and a special nature program is held during the summer. Information on these activities is published in the BULLETIN or may be had by mail or phone. The Garden maintains a research program through the Henry Shaw School of Botany, Washington University.

In 1926 an Arboretum — 1600 acres — was established at Gray Summit, Missouri. Foot trails and roads pass through the Arboretum and are open to visitors in April and May.

The Garden Administration Building is located at 2315 Tower Grove Ave., and the Garden main entrance is at Tower Grove and Flora Place. The entrance at Tower Grove and Cleveland Avenue is also open to the public. The Garden is served by both the Sarah (No. 42) and the Park-Southampton (No. 80) city bus lines.

Persons interested in helping to support the Garden and taking part in Garden activities are urged to do so through the "Friends of the Garden". Information may be obtained from the Main Gate or by mail or phone.